Adjustable Range Broadcast for Desired Airborne Network Connectivity

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Outline

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4. Maintaining Connectivity
5. Performance Measures
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7. Current Work
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1. Introduction

- Situational Awareness Is Essential for Safety
  - Air traffic has been increasing, UAVs are coming
  - Ground-based separation, Self-separation

- Three Current Approaches to Situational Awareness
  - (For commercial air traffic control)
  - Ground system sends up all aircraft data (TIS-B)
  - Each aircraft broadcasts its information (ADS-B)
  - Each aircraft measures others' information (TCAS I, II)

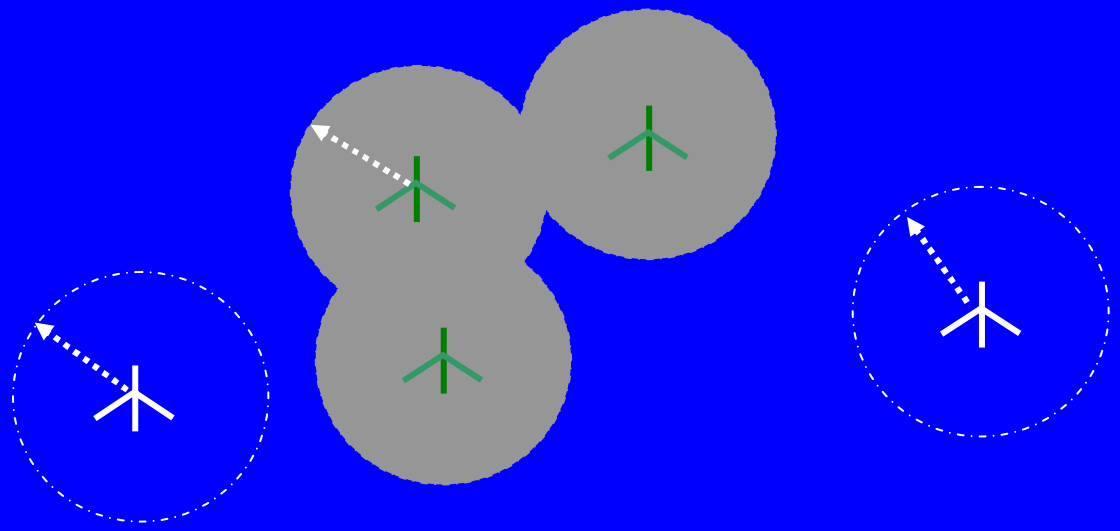
1. Introduction (Cont'd)

- Advantages of ADS-B
  - Low-cost, accuracy, wide applicable scenarios
  - FAA recommended 1090ES link, UAT

- Potential Problems of ADS-B
  - Limited range of a single digital link
    - 40 nm reliably for 1090 ES
  - Some applications may require longer range
  - Maximum flexibility of a single link not achieved

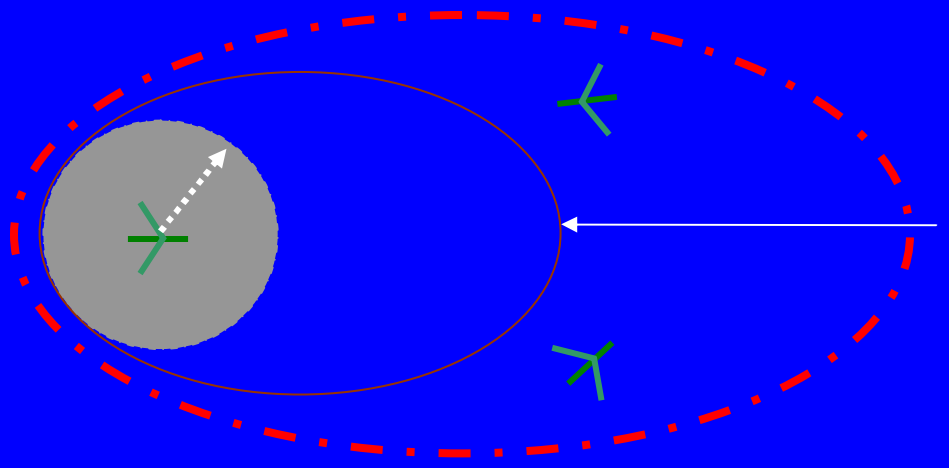
1. Introduction (Cont'd)

- An Airborne Network Idea (Cheng & Zhao 2004)
  - Each aircraft not only broadcasts it own information
  - But also relays information from other aircraft
  - UAVs can participate, can also serve as relays
- Much extended coverage range, Maximum flexibility



1. Introduction (Cont'd)

- The Concept of Desired Region of Connectivity
  - For Situational Awareness, Efficiency, Coordination
  - E.g. Required Action Range for Conflict Resolution



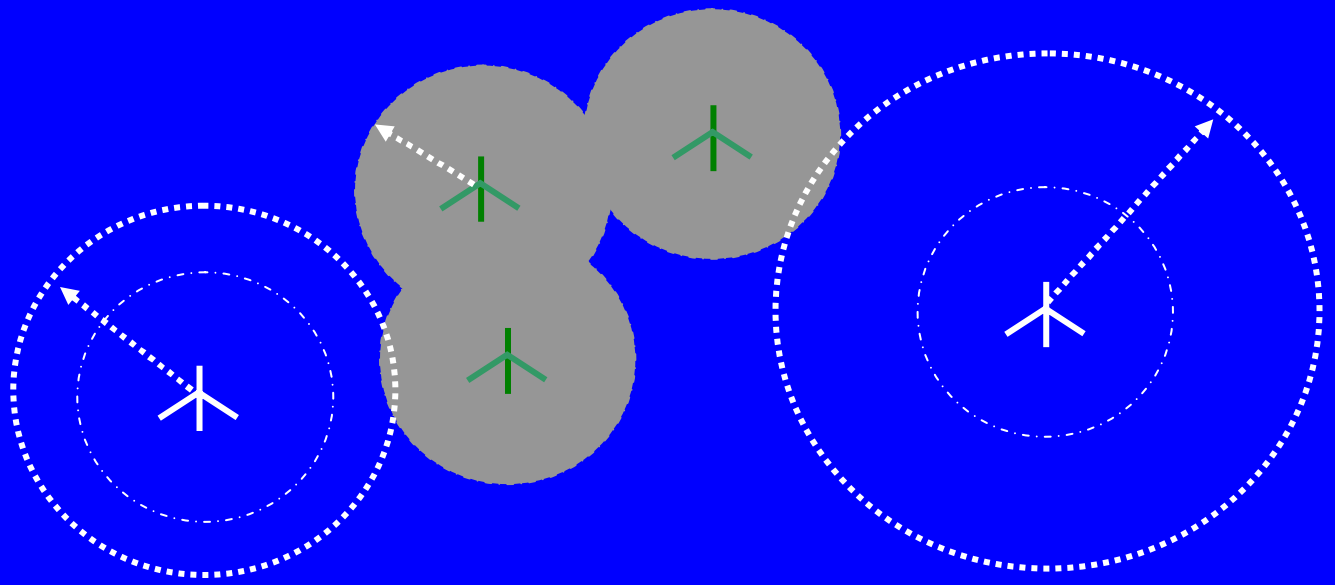
Required Action Range
(Kuo & Zhao, 2001)

1. Introduction (Cont'd)

- Features of Desired Region of Connectivity
  - Allow for adequate time/maneuver options for
    - Conflict resolution, Efficient flight planning
    - Flight coordination
  - Shape and size can vary, depending on
    - Performance capabilities, Traffic density
    - Surveillance needs
  - Dynamic coupling between flights and network
    - Projected connectivity over time for vehicle mobility

2. Adjustable-Range Airborne Network (ARAN)

- The Concept for Cooperative Case
  - Aircraft can adjust their broadcasting power as needed
  - To ensure connectivity over a specified region



2. Adjustable-Range Airborne Network (Cont'd)

- Some Potential Issues
  - Establishing initial connections
  - Maintaining connections
  - Performance measures
  - Un-cooperative case

3. Establishing Initial Connections

- Basic Information Needs
  - A/C need to know rough locations of others in the region
  - Individual A/C willing to adapt for group benefit
- Ground-based Approach
  - Ground stations send initial information up over a region
- Airborne Approach
  - Individual A/C use sufficiently large power initially
  - To establish connectivity over >= desired region

4. Maintaining Connectivity

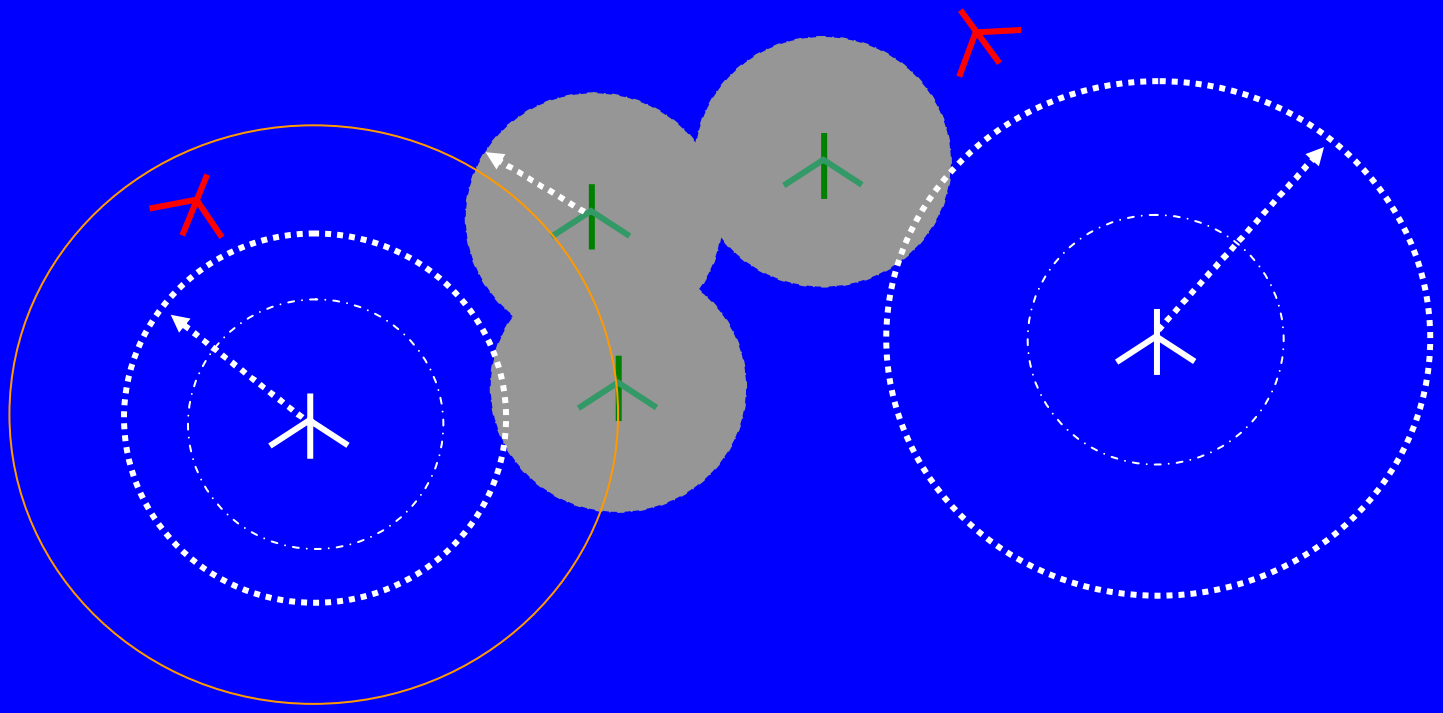
- Looking for Decentralized Algorithms for ARAN

1) Receiver Sends Requesting Signal to Sender Airplane
   - Ask for power increase when signal is too weak
   - But: original sender may not receive due to large distance
2) Receiver Sends Requesting Signal to Ground or SAT
   - Problem: Latency, due to the vehicle motions
3) Senders and Receivers Continuously Handshake
   - Communication overhead, but promising

5. Performance Measures of ARAN

- Coverage Ratio
  - % of connected A/C within region around a given A/C
  - Whose state info received by the A/C, <= certain time
  - Measures timely end-to-end transmission in the region
- Average Power Consumption
  - Measures the energy efficiency

6. Extension to Un-cooperative Case



- Surveillance Responsibility of Each Un-cooperative A/C
- Is Assigned to Ground or a Friendly A/C

7. Current Work

- Desired Connectivity Region for Various Scenarios
  - Conflict resolution
  - Planning for efficient flights
  - Team flight coordination
- Further Studies of Decentralized Schemes
  - Analyses of proposed schemes
- Simulation Studies
  - Vehicle motions described as point-mass models
  - Random errors introduced to transmission/reception
  - Integrated analysis of vehicle flights & network connectivity

8. Summary

- Proposed Concept of Adjustable-Range Airborne Network
- Analysis of Key Issues
- Preliminary Solution Schemes for Key Issues
- Current Work Being Conducted on Details